Markup sheets showing the changes to the specification and to the claims are included.

Please contact the undersigned if there are any questions.

Respectfully submitted,

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MARKUP SHEET SHOWING CLAIM AMENDMENTS MADE HEREIN

4. (Amended) The image forming device according to [one of claims 1-3] claim 1 wherein said pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

5. (Amended) The image forming device according to claim 1 [or 2] wherein said low-resolution position detecting means comprises a counter for counting a timing signal based on said linear scale and wherein said high-resolution position detecting means comprises a timer which is initialized by said timing signal and measures a time with a predetermined clock signal.

7. (Amended) The image forming device according to claim 1 [or 6] wherein said calculating means uses said pattern detecting means to detect the vertical bar at least two positions in a longitudinal direction of said vertical bar to obtain a print position of said vertical bar based on an average value of the detected results.

10. (Amended) The image forming device according to claim 1 [or 9] wherein, based on both edges of an obtained pattern element, said calculating means calculates a center position of a width of the pattern element.

heads are mounted, as shown in FIG. 14(b), sometimes generates horizontal stripes and results in an unevenly printed image.

In addition, on a device that uses a linear scale for establishing ink jet synchronization to jet ink at correct positions in the main scanning direction of the recording head, a jet position deviation (W2 + W3) may occur during forward and backward printing depending upon the movement speed of the carriage, sometimes resulting in an uneven image printing. This deviation is caused by a delay generated before the ink is jetted from the time of passing the slit position as shown in FIG. 14(c).

Therefore, when a color registration error (hereinafter called a registration deviation) occurs through the recording head replacement or for some other reasons, the individual recording heads must be registered (i.e. registration adjustment). A registration deviation amount must be detected before making the registration adjustment. There are two methods of detecting registration deviation amounts: one is to print a particular test pattern, designed to make a registration deviation readily detectable, on paper so that human beings can check the print result to manually detect a registration amount, and the other is to cause a sensor to read a test pattern to detect a registration deviation.

The technology for reading the test pattern via a sensor is disclosed in Japanese Patent Laid-Open Publication No. Hei 7-323582. As shown in FIG. 15, the base recording head, one of a plurality of recording heads, and each of the other recording

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heads print a pattern made up of two parallel bars (pattern elements) to allow the sensor to read the same position of the parallel bars twice to detect the recording head deviation amount. That is, in the first scan, the sensor senses the width of each pattern element to calculate the center dot position thereof. Then, in the second scan, the sensor senses the width W1 between the pattern elements of the base head, based on the center dot positions of the pattern elements. Repeating the above-described operation for the pattern element of the base head and those of the other heads to calculate the widths (distances) W2, ..., between the pattern elements of the base head and those of the other heads. Then, the head deviation amount ΔW is calculated based on the difference of those widths.

To do so, a comparator 1502 converts the analog signal, which is output from a sensor 1501, into a binary (bi-level) signal as shown in FIG. 16. In the first scan, this binary signal is sampled in a predetermined timing in accordance with a timer 1503. Each time a pattern element is read, a CPU 1505 references the value of the timer 1503 to read the pattern width data of each of two pattern elements. After the scan is terminated, the distance from the edge of the pattern element to the center dot is calculated from the scan speed and the sampling frequency, based on the width data of each of two pattern elements. After that, setting the center value of each pattern element in the timer 1503 immediately before the pattern is read in the second scan causes the timer 1503 to output a

carry signal at the time the carriage reaches the center position of the pattern element. By operating a timer 1504 using this carry signal, the distance between the center dot position of a pattern element and that of another pattern element is calculated. This is done for the pattern elements of the base head and for the pattern elements of the base head and other heads to calculate the head deviation amount ΔW.

However, in this case, the signal is sampled in a predetermined timing. Therefore, the carriage speed varies during carriage scanning, from scan to scan, or from device to device due to various mechanical factors such as the tension of a drive belt connecting the carriage and the motor. This variation is accumulated in the sampling results, sometimes affecting the precision of registration adjustment. In addition, detecting each pattern-to-pattern width W1, W2, ... requires the carriage to scan twice, thus requiring a long detection time and, at the same time, doubling the accumulation variation.

This applies also to the paper conveyance direction. Variations in the paper conveyance roller diameter, eccentricity, and gears connecting the motor to the roller generate accumulation variations in the accumulated sampling results.

In view of the foregoing, it is an object of the present invention to provide an image forming device capable of precisely detecting a recording head deviation when the recording head has been replaced.

operation of the carriage 106 (and head 101) and the paper feed operation in this way records an entire image.

A linear scale 109 provided next to, and parallel with, the scanning path of the carriage 106 has slits provided therealong at a predetermined resolution (resolution). A transmission type optical sensor (1203 in FIG. 12) installed near the carriage 106 reads the slits on the linear scale 109 to obtain two signals each with its own phase (90° out of phase). These signals are used to manage the position of the carriage 106 and, at the same time, synchronize the ink jet from the recording head 101.

In this embodiment, a recording head with the resolution of 600 dots/inch and a linear scale with the resolution of 600 dots/inch are used to allow an image to be printed at 600 dots/inch.

Also provided near the carriage 106 in this embodiment is a reflective type optical sensor 110. When any of the recording heads 101 on the carriage 106 cannot form a good image because any of plural recording elements are damaged or ink is not jetted from those elements, the recording head must be replaced. When some of a plurality of recording heads or all of them have been replaced or when the positional relationship among the plurality of recording heads is not correct for some reasons, the images, each formed in a color, are not registered correctly. This is a serious problem because a good image cannot be obtained. Therefore, when a color deviation (registration deviation) occurs at head replacement time or for some reasons, the positions of the recording heads must be